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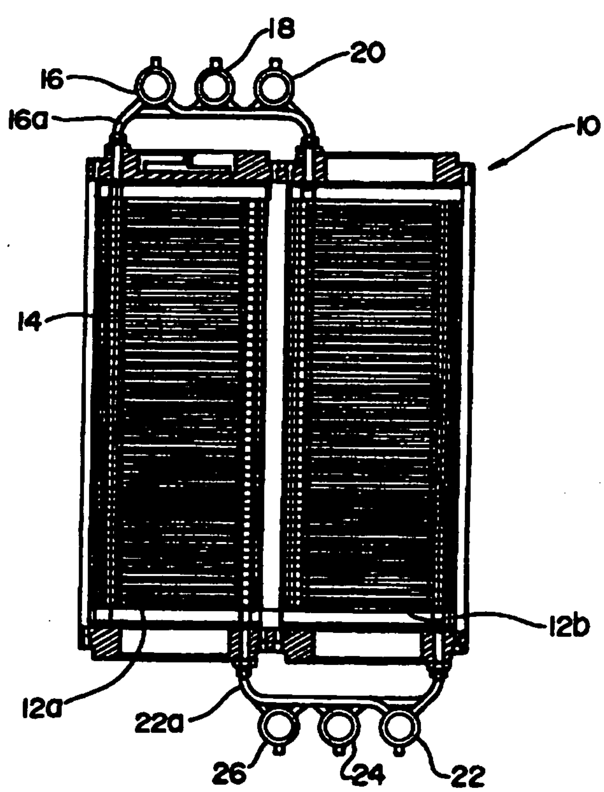
(57) Abstract

An integrated external manifold assembly conducts fluid streams to and from, and fluidly communicates the fluid streams with, a plurality of electrochemical fuel cell stacks (12a, 12b). The assembly comprises at least one manifold header conduit (16, 18, 20) and a plurality of manifold branch conduits (16a) integrally connected to and extending from each of the manifold header conduits. Each of the manifold header conduits is fluidly connected to one of an inlet or an outlet fluid stream. Each of the manifold branch conduits fluidly connects the manifold header conduit from which it extends to one of the plurality of stacks.



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INTEGRATED EXTERNAL MANIFOLD ASSEMBLY FOR AN ELECTROCHEMICAL FUEL CELL STACK ARRAY

Field Of The Invention

The present invention relates to an electrochemical fuel cells. More particularly, the present invention relates to an integrated external manifold assembly for conducting and introducing the inlet reactant and coolant streams to an array of electrochemical fuel cell stacks and/or for receiving and conducting the outlet reactant and coolant streams from an array of electrochemical fuel cell stacks.

Background Of The Invention

Electrochemical fuel cells convert fuel and oxidant to electricity and reaction product. Solid polymer electrochemical fuel cells generally employ a membrane electrode assembly ("MEA") consisting of a solid polymer electrolyte or ion exchange membrane disposed between two electrodes formed of porous, electrically conductive sheet material, typically carbon fiber paper. The MEA contains a layer of catalyst, typically in the form of finely comminuted platinum, at each membrane/electrode interface to induce the desired electrochemical reaction. The electrodes are electrically coupled to provide a path for conducting electrons between the electrodes to an external load.

At the anode, the fuel permeates the porous electrode material and reacts at the catalyst layer to form cations, which migrate through the membrane to the cathode. At the cathode, the oxygen-

containing gas supply reacts at the catalyst layer to form anions. The anions formed at the cathode react with the cations to form a reaction product.

In electrochemical fuel cells employing hydrogen as the fuel and oxygen-containing air (or substantially pure oxygen) as the oxidant, the catalyzed reaction at the anode produces hydrogen cations (protons) from the fuel supply. The ion exchange membrane facilitates the migration of hydrogen ions from the anode to the cathode. In addition to conducting hydrogen ions, the membrane isolates the hydrogen-containing fuel stream from the oxygen-containing oxidant stream. At the cathode, oxygen reacts at the catalyst layer to form anions. The anions formed at the cathode react with the hydrogen ions that have crossed the membrane to form liquid water as the reaction product. The anode and cathode reactions in hydrogen/oxygen fuel cells are shown in the following equations:

Anode reaction: $H_2 \rightarrow 2H^+ + 2e^-$

Cathode reaction: $1/2O_2 + 2H^+ + 2e^- \rightarrow H_2O$

In typical fuel cells, the MEA is disposed between two electrically conductive plates, each of which has at least one flow passage engraved or milled therein. These fluid flow field plates are typically formed of graphite. The flow passages direct the fuel and oxidant to the respective electrodes, namely, the anode on the fuel side and the cathode on the oxidant side. In a single cell arrangement, fluid flow field plates are provided

on each of the anode and cathode sides. The plates act as current collectors, provide support for the electrodes, provide access channels for the fuel and oxidant to the respective anode and cathode surfaces, and provide channels for the removal of water formed during operation of the cell.

Two or more fuel cells can be connected together, generally in series but sometimes in parallel, to increase the overall power output of the assembly. In series arrangements, one side of a given plate serves as an anode plate for one cell and the other side of the plate can serve as the cathode plate for the adjacent cell. Such a series connected multiple fuel cell arrangement is referred to as a fuel cell stack, and is usually held together in its assembled state by tie rods and end plates. The stack typically includes manifolds and inlet ports for directing the fuel (substantially pure hydrogen, methanol reformate or natural gas reformate) and the oxidant (substantially pure oxygen or oxygen-containing air) to the anode and cathode flow field channels. The stack also usually includes a manifold and inlet port for directing the coolant fluid, typically water, to interior channels within the stack to absorb heat generated by the exothermic reaction of hydrogen and oxygen within the fuel cells. The stack also generally includes exhaust manifolds and outlet ports for expelling the unreacted fuel and oxidant gases, each carrying entrained water, as well as an exhaust manifold and outlet port for the coolant water exiting the stack. It is generally convenient to locate all of the inlet ports at the same end of the stack and

all of the outlet ports at the same end of the stack.

Multiple stacks can be arranged, either in series or in parallel, in an array to increase the overall power output. In such stack arrays, it is generally convenient to locate all of the inlet ports of the individual stacks at one end of the array and all of the outlet ports of the individual stacks at the other end of the array. Moreover, it is advantageous to orient the array vertically such that the inlet ports of the individual stacks are located at the top of the array and the outlet ports are located at the bottom of the array. Such an orientation capitalizes on the effects of gravity in urging water entrained in the outlet reactant streams downwardly through the stack toward the outlet ports of the individual stacks. While the foregoing an orientation is advantageous, other orientations of the fuel cell stack array are possible as well, such as, for example, horizontally, diagonally, and vertically with the outlet ports located at the top of the array and the inlet ports are located at the bottom of the array.

Summary Of The Invention

An integrated external manifold assembly conducts at least one fluid stream to or from, and fluidly communicates the at least one fluid stream with, a plurality of electrochemical fuel cell stacks. The assembly comprises:

(a) at least one manifold header conduit, each of the at least one manifold header conduit fluidly connected to one of an

inlet or an outlet fluid stream;

(b) a plurality of manifold branch conduits integrally connected to and extending from each of the at least one manifold header conduit, each of the manifold branch conduits fluidly connecting the manifold header conduit from which it extends to one of the plurality of stacks.

In the preferred manifold assembly, the at least one fluid stream comprises a plurality of reactant and coolant streams, and the at least one manifold header conduit comprises a plurality of manifold header conduits each of which is fluidly connected to one of the plurality of reactant and coolant streams. The plurality of fluid streams more preferably comprises a fuel stream, an oxidant stream, and a coolant stream. In the most preferred manifold assembly, each of the fuel cells forming the stack comprises a proton exchange membrane and the plurality of fluid streams comprises a hydrogen-containing fuel stream, an oxygen-containing oxidant stream, and a coolant stream.

Each of the at least one manifold header conduit can comprise a plurality of conduit segments.

The at least one manifold header conduit and the manifold branch conduits are preferably formed from an electrically and thermally insulating material, most preferably a moldable thermoplastic or thermoset material.

An improved electrochemical fuel cell stack array comprises a plurality of electrochemical fuel

cell stacks and a manifold assembly for conducting at least one fluid stream to or from, and fluidly communicating the at least one fluid stream with, the plurality of stacks. The assembly comprises:

(a) at least one manifold header conduit, each of the at least one manifold header conduit fluidly connected to one of an inlet or an outlet fluid stream;

(b) a plurality of manifold branch conduits integrally connected to and extending from each of the at least one manifold header conduit, each of the manifold branch conduits fluidly connecting the manifold header conduit from which it extends to one of the plurality of stacks.

Brief Description Of The Drawings

FIG. 1 is a side elevation view of an electrochemical fuel cell stack array having a upper external manifold assembly for conducting and introducing the inlet reactant and coolant streams to an array of electrochemical fuel cell stacks and a lower external manifold assembly for receiving and conducting the outlet reactant and coolant streams from an array of electrochemical fuel cell stacks.

FIG. 2 is a top view, looking downwardly, of the electrochemical fuel cell stack array illustrated in FIG. 1.

FIG. 3 is a perspective view of one of the external manifold assemblies illustrated in FIG. 1.

FIG. 4 is plan view of the external manifold assemblies illustrated in FIG. 3.

FIG. 5 is a side elevation view of the external manifold assembly illustrated in FIG. 3.

FIG. 6 is a sectional view of the external manifold assembly taken in the direction of arrows 6-6 in FIG. 4.

Detailed Description Of The Preferred Embodiments

Turning first to FIG. 1, an electrochemical fuel cell stack array 10 includes four fuel cell stacks, two of which are illustrated in FIG. 1 as stacks 12a and 12b. Each stack is in turn composed of a plurality of individual fuel cells, one of which is designated in FIG. 1 as fuel cell 14. A fuel cell stack 10 is more completely described in Watkins et al. U.S. Patent No. 5,200,278 (in FIGS. 1-6 and the accompanying text), which is incorporated herein by reference in its entirety. A preferred reactant supply and control system for fuel cells of the type which make up stack array 10 is described in Merritt et al. U.S. Patent No. 5,366,821, which is also incorporated herein by reference in its entirety.

As shown in FIG. 1, the inlet reactant (preferably a hydrogen-containing fuel stream and an oxygen-containing oxidant stream) and coolant streams are directed to stack array 10 by an external manifold assembly which includes manifold header conduits 16, 18, 20. Each of the inlet reactant and coolant streams is in turn directed to the individual stacks by a plurality of manifold branch conduits. The manifold branch conduit for directing the inlet reactant stream from manifold header conduit 16 to stack 12a is designated in FIG. 1 as manifold branch conduit 16a.

As further shown in FIG. 1, the outlet reactant and coolant streams are directed from the individual stacks by a plurality of manifold branch conduits. The manifold conduit for directing the outlet reactant stream from stack 12a to manifold header conduit 22 is designated in FIG. 1 as manifold branch conduit 22a. Each of the outlet reactant and coolant streams is in turn directed from stack array 10 by an external manifold assembly which includes manifolds header conduits 22, 24, 26.

FIG. 2 is a top view of stack array 10, showing each of the four fuel cell stacks 12a, 12b, 12c, 12d, as well as the manifold header conduits 16, 18, 20 for directing the inlet reactant and coolant streams to stack array 10. Manifold branch conduit 16a directs the reactant stream from manifold header conduit 16 to stack 12a.

FIGS. 3-6 shows one of the external manifold assemblies 100 illustrated in FIG. 1. As best shown in FIGS. 3 and 4, external manifold assembly 100 includes three manifold header conduits 102, 104, 106. Manifold header conduit 102 is fluidly connected to the inlet fuel stream, preferably a hydrogen-containing gas stream. Manifold header conduit 104 is fluidly connected to the inlet coolant stream, preferably a liquid water stream. Manifold header conduit 106 is fluidly connected to the inlet oxidant stream, preferably a oxygen-containing gas stream. Each of manifold header conduits 102, 104, 106 includes a ferrule portion 102a, 104a, 106a, respectively, for fluidly connecting the header conduits to the inlet fuel, oxidant and coolant sources. Each of the manifold

header conduits 102, 104, 106 also includes a terminal cap portion 102b, 104b, 106b, respectively, for sealing the header conduit. In some configurations, the terminal cap portions 102b, 104b, 106b could be removable to permit the connection of further header conduit segments, thereby extending the length and accommodating a greater number of branch conduits extending from each manifold header conduit.

As further shown in FIGS. 3 and 4, four manifold branch conduits 112a, 112b, 112c, 112d extend from manifold header conduit 102. The proximal end of each manifold branch conduit 112a, 112b, 112c, 112d is integrally connected to manifold header conduit 102, while the distal end of each manifold branch conduit 112a, 112b, 112c, 112d is fluidly connected to the fuel stream inlet of the corresponding fuel cell stack (not shown in FIG. 3). Similarly, four manifold branch conduits 114a, 114b, 114c, 114d extend from manifold header conduit 104. The proximal end of each manifold branch conduit 114a, 114b, 114c, 114d is integrally connected to manifold header conduit 104, while the distal end of each manifold branch conduit 114a, 114b, 114c, 114d is fluidly connected to the coolant stream inlet of the corresponding fuel cell stack (not shown in FIG. 3). Likewise, four manifold branch conduits 116a, 116b, 116c, 116d extend from manifold header conduit 106. The proximal end of each manifold branch conduit 116a, 116b, 116c, 116d is integrally connected to manifold header conduit 106, while the distal end of each manifold branch conduits 116a, 116b, 116c, 116d is fluidly connected to the oxidant stream

inlet of the corresponding fuel cell stack (not shown in FIG. 3). Flanges located at the distal end of each of the manifold branch conduits, one of which is illustrated in FIGS. 3-5 as flange 122, form the fluid connection between the manifold branch conduits and the corresponding inlet of the respective fuel cell stack. A fastener (not shown in FIG. 3), such as, for example, a fastening nut, extends through the opening in flange 122 into a corresponding threaded opening in the adjacent fuel cell stack.

The term "integrally connected" means that the walls of the manifold branch conduits are substantially coextensive with the manifold header conduit from which they extend. Integrally connected structures include those in which the manifold header and branch conduits are simultaneously injection or compression molded as one continuous piece, and also includes structures in which the manifold branch conduits are substantially permanently bonded to the corresponding manifold header conduit, such as, for example, with an epoxy adhesive. Flexible structures, such for example, manifold branch conduits formed from bendable hoses which extend from manifold header conduits using valves, nozzles or other readily disconnectable means are not considered to be integrally connected.

FIG. 6 shows a sectional view of the external manifold assembly 100 taken in the direction of arrows 6-6 in FIG. 4. As best shown in FIG. 6, the manifold header conduits 102, 104, 106 are integrally formed with the manifold branch conduits 116a, 116d, preferably by injection molding.

The external manifold assembly of the present invention is preferably formed from an electrically and thermally insulating thermoplastic or thermoset material. The preferred material avoids the condensation of humidified reactant streams, provides electrical and thermal isolation, is relatively inexpensive, is readily injection moldable, lightweight, chemically inert and chemically resistant, impervious to water absorption, and capable of being formed into a variety of structural and geometric configurations.

The advantages of the present integrated external manifold assembly are as follows:

(1) the present external manifold assembly simultaneously accommodates multiple fluid streams;

(2) the present external manifold assembly substantially equally distributes the fluid streams to each of the plurality of fuel cell stacks forming the array;

(3) the present external manifold assembly exhibits low pressure drops in conducting the fluid streams; and

(4) the present external manifold assembly can be readily formed with uniform or non-uniform conduit wall thickness, as desired, so that the temperature remains substantially uniform or otherwise controlled across the entire manifold assembly.

While particular elements, embodiments and applications of the present invention have been shown and described, it will be understood, of course, that the invention is not limited thereto

since modifications may be made by those skilled in the art, particularly in light of the foregoing teachings. It is therefore contemplated by the appended claims to cover such modifications as incorporate those features which come within the spirit and scope of the invention.

What is claimed is:

1. A manifold assembly for conducting at least one fluid stream to or from, and fluidly communicating said at least one fluid stream with, a plurality of electrochemical fuel cell stacks, said assembly comprising:

(a) at least one manifold header conduit, each of said at least one manifold header conduit fluidly connected to one of an inlet or an outlet fluid stream;

(b) a plurality of manifold branch conduits integrally connected to and extending from each of said at least one manifold header conduit, each of said manifold branch conduits fluidly connecting the manifold header conduit from which it extends to one of said plurality of stacks.

2. The manifold assembly of claim 1 wherein said at least one fluid stream comprises a plurality of reactant and coolant streams, and wherein said at least one manifold header conduit comprises a plurality of manifold header conduits each of which is fluidly connected to one of said plurality of reactant and coolant streams.

3. The manifold assembly of claim 2 wherein said plurality of fluid streams comprises a fuel stream, an oxidant stream, and a coolant stream.

4. The manifold assembly of claim 3 wherein each of the fuel cells forming said stack comprises

a proton exchange membrane and said plurality of fluid streams comprises a hydrogen-containing fuel stream, an oxygen-containing oxidant stream, and a coolant stream.

5. The manifold assembly of claim 1 wherein each of said at least one manifold header conduit comprises a plurality of conduit segments.

6. The manifold assembly of claim 1 wherein said at least one manifold header conduit and said manifold branch conduits are formed from an electrically and thermally insulating material.

7. The manifold assembly of claim 6 wherein said electrically and thermally insulating material is a moldable thermoplastic or thermoset material.

8. An electrochemical fuel cell stack array comprising a plurality of electrochemical fuel cell stacks and a manifold assembly for conducting at least one fluid stream to or from, and fluidly communicating said at least one fluid stream with, said plurality of stacks, said assembly comprising:

(a) at least one manifold header conduit, each of said at least one manifold header conduit fluidly connected to one of an inlet or an outlet fluid stream;

(b) a plurality of manifold branch conduits integrally connected to and extending from each of said at least one manifold header conduit, each of said manifold branch conduits fluidly connecting the manifold header conduit from which it

extends to one of said plurality of stacks.

9. The fuel cell stack array of claim 8 wherein said at least one fluid stream comprises a plurality of reactant and coolant streams, and wherein said at least one manifold header conduit comprises a plurality of manifold header conduits each of which is fluidly connected to one of said plurality of reactant and coolant streams.

10. The fuel cell stack array of claim 9 wherein said plurality of fluid streams comprises a fuel stream, an oxidant stream, and a coolant stream.

11. The fuel cell stack array of claim 10 wherein each of the fuel cells forming said stack comprises a proton exchange membrane and said plurality of fluid streams comprises a hydrogen-containing fuel stream, an oxygen-containing oxidant stream, and a coolant stream.

12. The fuel cell stack array of claim 8 wherein each of said at least one manifold header conduit comprises a plurality of conduit segments.

13. The fuel cell stack array of claim 8 wherein said at least one manifold header conduit and said manifold branch conduits are formed from an electrically and thermally insulating material.

14. The fuel cell stack array of claim 13 wherein said electrically and thermally insulating

material is a moldable thermoplastic or thermoset material.

AMENDED CLAIMS

[received by the International Bureau on 31 May 1996(31.05.96); original claims 1-6 and 8-13 amended; new claims 15-20 added; remaining claims unchanged (4 pages)]

1. A manifold assembly for conducting at least two fluid streams to or from, and fluidly communicating each of said at least two fluid streams with, a plurality of electrochemical fuel cell stacks, said assembly comprising:

(a) at least two manifold header conduits, each of said at least two manifold header conduits fluidly connected to one of an inlet or an outlet fluid stream;

(b) a plurality of manifold branch conduits integrally connected to and extending from each of said at least two manifold header conduits, each of said manifold branch conduits fluidly connecting the manifold header conduit from which it extends to one of said plurality of stacks.

2. The manifold assembly of claim 1 wherein said at least two fluid streams comprise at least one reactant stream and at least one coolant stream.

3. The manifold assembly of claim 2 wherein said at least one reactant stream comprises a fuel stream and an oxidant stream.

4. The manifold assembly of claim 3 wherein each of the fuel cells forming said stack comprises a proton exchange membrane and said at least one reactant stream comprises a hydrogen-containing fuel stream and an oxygen-containing oxidant stream.

5. The manifold assembly of claim 1 wherein each of said at least two manifold header conduits comprises a plurality of conduit segments.

6. The manifold assembly of claim 1 wherein said at least two manifold header conduits and said manifold branch conduits are each formed from an electrically and thermally insulating material.

7. The manifold assembly of claim 6 wherein said electrically and thermally insulating material is a moldable thermoplastic or thermoset material.

8. An electrochemical fuel cell stack array comprising a plurality of electrochemical fuel cell stacks and a manifold assembly for conducting at least two fluid streams to or from, and fluidly communicating said at least two fluid streams with, said plurality of stacks, said assembly comprising:

(a) at least two manifold header conduits, each of said at least two manifold header conduits fluidly connected to one of an inlet or an outlet fluid stream;

(b) a plurality of manifold branch conduits integrally connected to and extending from each of said at least two manifold header conduits, each of said manifold branch conduits fluidly connecting the manifold header conduit from which it extends to one of said plurality of stacks.

9. The fuel cell stack array of claim 8 wherein said at least two fluid streams comprise at least one reactant stream and at least one coolant stream.

10. The fuel cell stack array of claim 9 wherein said at least one reactant stream comprises a fuel stream and an oxidant stream.

11. The fuel cell stack array of claim 10 wherein each of the fuel cells forming said stack comprises a proton exchange membrane and said at least one reactant stream comprises a hydrogen-containing fuel stream and an oxygen-containing oxidant stream.

12. The fuel cell stack array of claim 8 wherein each of said at least two manifold header conduits comprises a plurality of conduit segments.

13. The fuel cell stack array of claim 8 wherein said at least two manifold header conduits and said manifold branch conduits are each formed from an electrically and thermally insulating material.

14. The fuel cell stack array of claim 13 wherein said electrically and thermally insulating material is a moldable thermoplastic or thermoset material.

15. The manifold assembly of claim 1 wherein said at least two fluid streams comprise at least two reactant streams.

16. The manifold assembly of claim 15 wherein said at least two reactant streams comprise a fuel stream and an oxidant stream.

17. The manifold assembly of claim 16 wherein each of the fuel cells forming said stack comprises a proton exchange membrane and said at least two reactant streams comprise a hydrogen-containing fuel stream and an oxygen-containing oxidant stream.

18. The fuel cell stack array of claim 8 wherein said at least two fluid streams comprise at least two reactant streams.

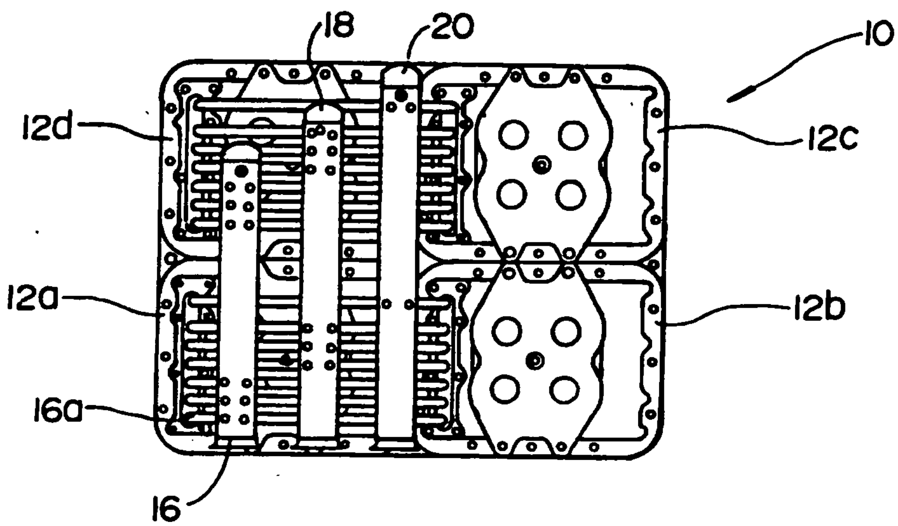
19. The fuel cell stack array of claim 18 wherein said at least two reactant streams comprise a fuel stream and an oxidant stream.

20. The fuel cell stack array of claim 19 wherein each of the fuel cells forming said stack comprises a proton exchange membrane and said at least two reactant streams comprise a hydrogen-containing fuel stream and an oxygen-containing oxidant stream.

STATEMENT UNDER ARTICLE 19(1)

The claims have been amended to specify that applicant's claimed integrated manifold assembly conducts at least two fluid streams to or from a plurality of electrochemical fuel cell stacks. Accordingly, the claimed manifold assembly, as amended, comprises at least two manifold header conduits, each of which is fluidly connected to one of an inlet or an outlet fluid stream, and a plurality of manifold branch conduits integrally connected to and extending from each of the manifold header conduits. Each of the manifold branch conduits fluidly connects the manifold header conduit from which it extends to one of the plurality of stacks.

FIG. 2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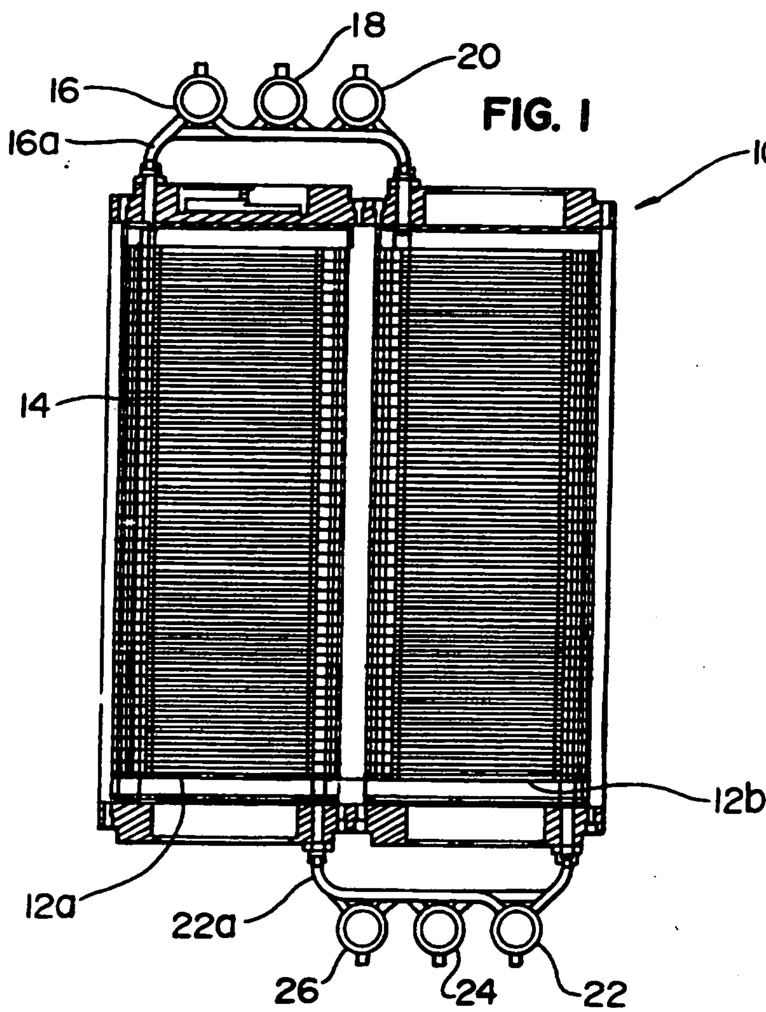
12b
16a
16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12b
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22a
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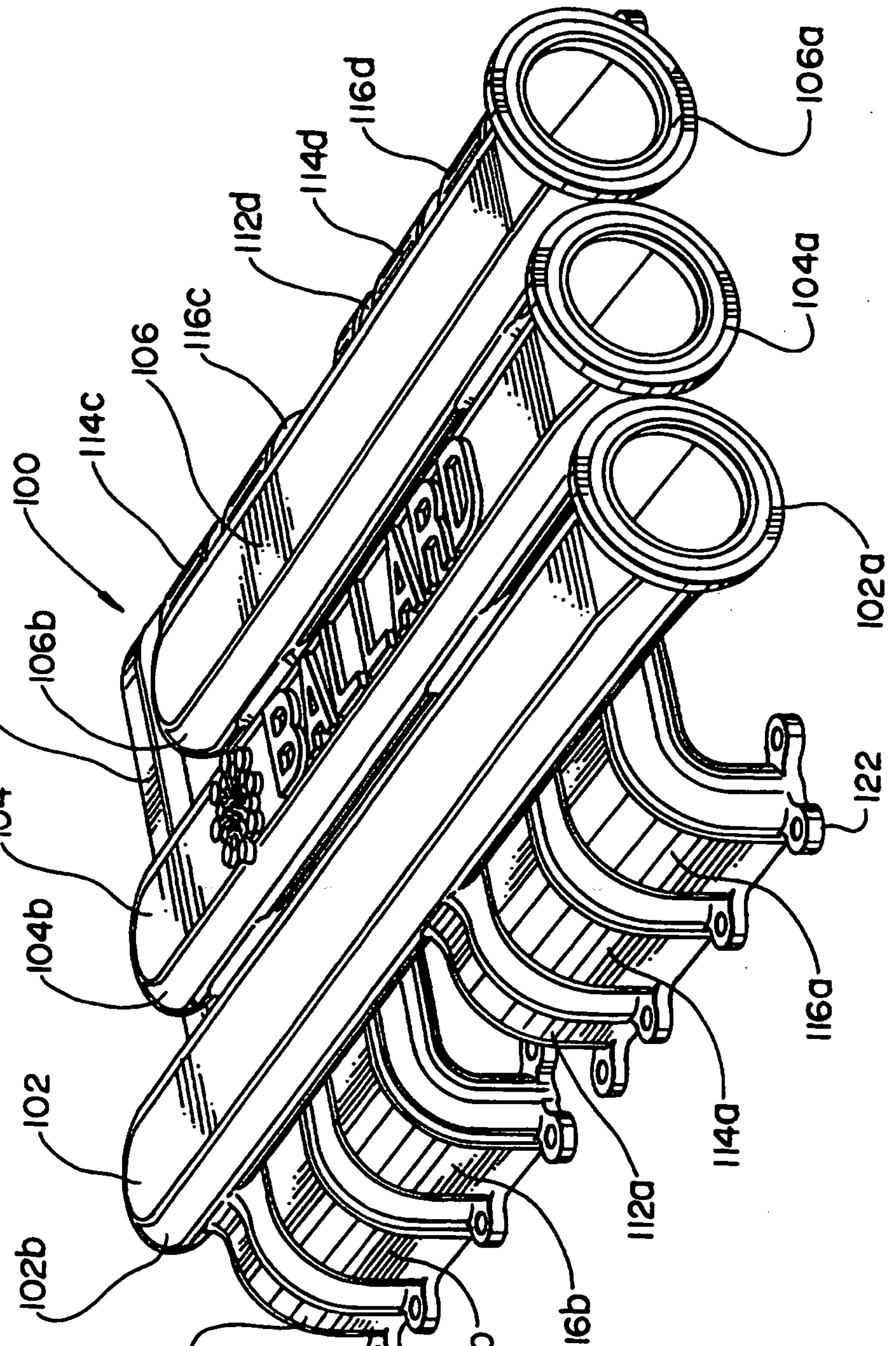
22

FIG. 1

FIG. 3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106b
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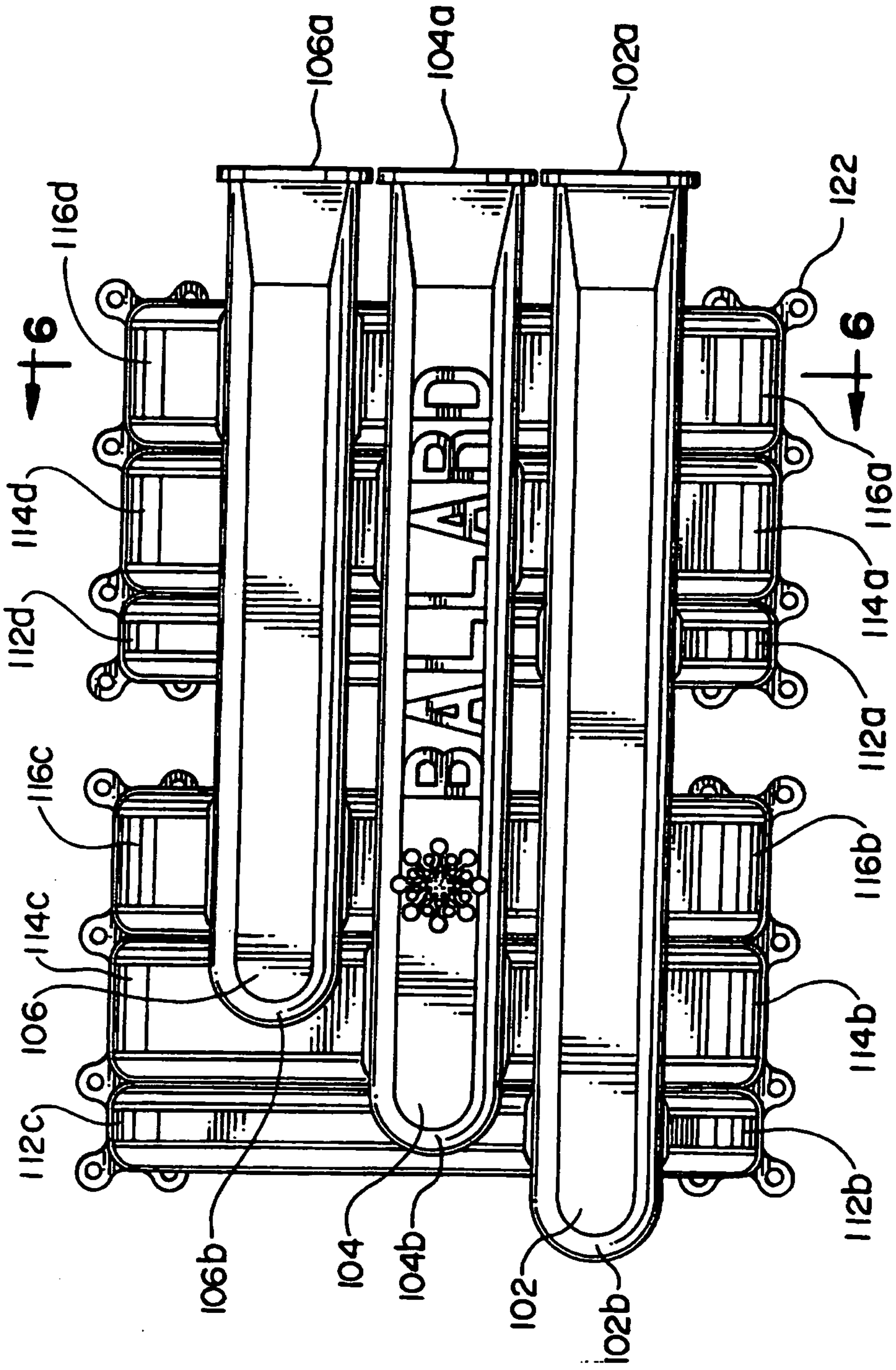
116d
122
BALLARD

FIG. 4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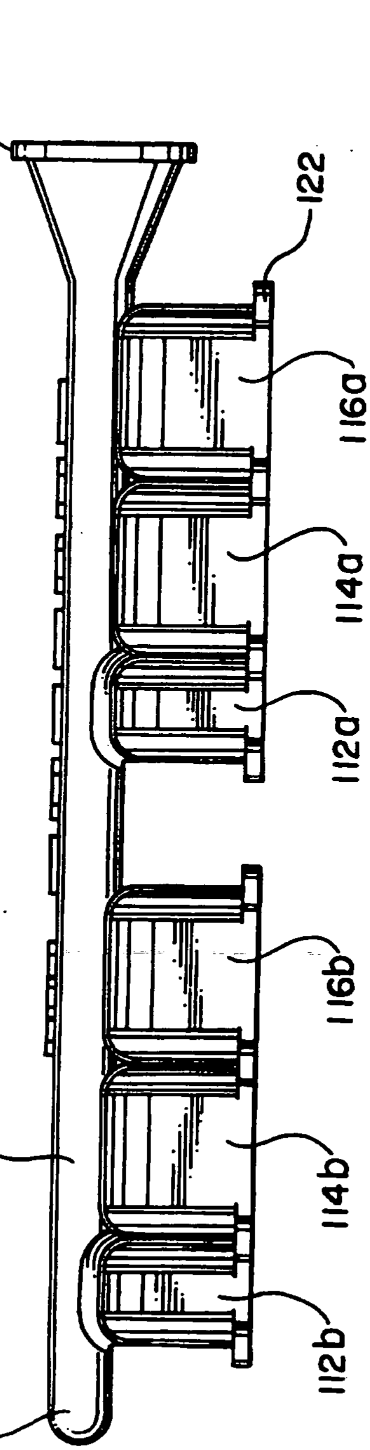
102b
BALLARD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116b
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112b
102
102b

FIG. 5

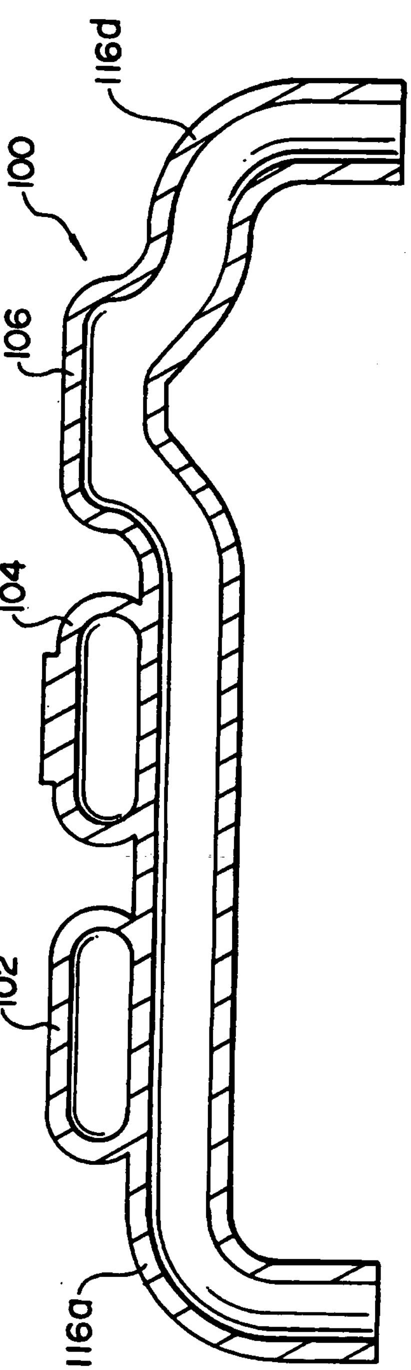
116d
100
106
104
102
116a

FIG. 6

INTERNATIONAL SEARCH REPORT

International Application No
PCT/CA 95/00719

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H01M8/24

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H01M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB,A,2 000 626 (ELECTROCHEM ENERGIECONVERSIE) 10 January 1979 see page 2, line 112 - line 129; figures 1,2 see page 3, line 11 - line 28 see page 3, line 58 - line 63 ---	1-3, 5-10, 12-14
X	PATENT ABSTRACTS OF JAPAN vol. 010 no. 283 (E-440) ,26 September 1986 & JP,A,61 101967 (TOSHIBA CORP) 20 May 1986, see abstract ---	1-3,8

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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1

Date of the actual completion of the international search	Date of mailing of the international search report
18 March 1996	02.04.96
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer D'hondt, J

INTERNATIONAL SEARCH REPORT

Int. ional Application No
PCT/CA 95/00719

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